The Role of Globalization in Energy Consumption: A Quantile Cointegrating Regression Approach

Muhammad Shahbaz and Amine Lahiani and Salah Abosedra and Shawkat Hammoudeh

Montpellier Business School, Montpellier, France, LEO – University of Orléans, France, American University in the Emirates, Dubai, UAE, Lebow College of Business, Drexel University, United States

2 February 2018

The Role of Globalization in Energy Consumption: A Quantile Cointegrating Regression Approach

Muhammad Shahbaz
Montpellier Business School,
Montpellier, France
Email: muhdshahbaz77@gmail.com

Amine Lahiani
LEO – University of Orléans, France
Montpellier Business School, Montpellier, France
Email: amine.lahiani@univ-orleans.fr

Salah Abosedra
College of Business Administration,
American University in the Emirates, Dubai, UAE.
Email: salaheddin.abosedra@lau.edu.lb

Shawkat Hammoudeh
Lebow College of Business, Drexel University, United States
Montpellier Business School, Montpellier, France
Email: shawkat.hammoudeh@drexel.edu

Abstract: This paper examines the quantile behavior of the relationship between the nuances of globalization and energy consumption while incorporating capital and economic growth in case of top-two most globalized countries – Netherlands and Ireland - by employing the recently developed quantile autoregressive distributed lag (QARDL) model of Cho et al. (2015). The model is estimated using quarterly data over the period 1970Q1-2015Q4. The results indicate that the relationship is quantile-dependent, which may reveal misleading results in studies using traditional analyses that address the averages. The Wald test confirms our findings by rejecting the null hypothesis of parameter constancy for both the Netherlands and Ireland. The changes in energy consumption are more responsive to past levels and past changes in globalization than the adjustment provided by the error-correction method (ECM). Interestingly, the findings indicate that globalization is positively correlated with energy consumption in the long-term for the two countries. Furthermore, globalization shares a robust long-term relationship with energy consumption. Energy consumption is strongly related to globalization in the long-term. However, the short-term effects of globalization on energy demand are limited for those countries. Important policy implications are then suggested based on the empirical results.

JEL Classification: F3, O1, Q4

Keywords: Globalization nuances, Energy Consumption, Quantile ARDL.

1. Introduction

Experts state that oil impacts virtually every important sector of the economy. We can add that the role of energy in the growth process has been immensely important, particularly since the strong winds of globalization began to blow in the early 1980s. Oil is one global common pool, and energy products, resources and pipelines do cross country borders that have been enhanced by globalization. Over the past three decades, academics have persistently devoted a great deal of time to studying the linkage between globalization and energy consumption. The theoretical tenet is straightforward and very simple: as the world becomes more globalized, total energy consumption will change. However, this change in energy consumption can be increased or decreased depending on the net impact of several factors among them is globalization. The increase in the total level of the world's economic output and the income associated with globalization and the removal of trade barriers have been perceived to be pushing energy consumption to higher levels. Therefore, the expansion of globalization is usually associated with an expanded use of energy due to the established empirical connection between economic growth and energy consumption, which has been observed in the existing literature. But this finding is debatable since other recent studies in the literature find a reverse effect of globalization on energy consumption. For example, using a panel of 25 countries, Shahbaz et al. (2017) find that globalization is positively linked to energy consumption in 12 countries, but negatively linked to energy consumption in the USA and UK. However, those same authors' results show that globalization does not influence energy consumption in other 11 countries. In another study, Shahbaz et al. (2016) report that acceleration of globalization leads to a decline of energy demand in India.

Supporting the favorable view is the argument that rapidly growing exporting economies, such as China and India, have benefited from the shift in manufacturing away from the US, Western Europe and other developed countries to these developing countries. The shift has resulted in more energy consumption for three reasons. First, even though the energy intensity is showing a downward trend worldwide, however it remains much higher in China than that in India, Europe or North America (Global Energy Statistical Yearbook, 2017). In fact, China accounts for a large part of the growth in the global energy demand. Second, the rules related to energy efficiency and their environmental consequences are looser in China and India than in developed countries. Consequently, globalization is believed to have caused an expansion in global energy demand and an increase in the emissions of greenhouse gases, which have negative consequences on the environment. Third, as the income level of people in growing exporting economies increases, their level of energy consumption will also increase.

However, the increase in income and exports proceeds will ultimately supplement domestic capital stock, know-how and technological spillovers for local industries in these exporting economies. This impact of globalization will take time to establish its influence but will eventually reduce energy consumption per unit of GDP and lead to decreasing emissions of greenhouse gases, thus creating positive environmental consequences in the long-term. Considering that the service sectors in the U.S., Western Europe and other developed countries are also impacted by globalization, where many jobs are shifted from these economies to developing countries, and considering that the consumption of energy per unit of GDP in this sector is lower than in other sectors, global energy consumption will likely change because of this shift[1].

Based on this narrative, we argue that globalization (i.e., worldwide movement toward economic, financial, trade, and communications integration) does not hit all countries at the same

[1]http://www.manzellareport.com/index.php/u-s/469-the-impact-of-globalization-trade-agreements-and-emerging-trade-blocs-on-us-industry

time or at the same intensity; thus, there will be globalization leaders and laggards over time, resulting in having a variety of most and least globalized countries. Moreover, globalization shifts between countries cause changes in energy consumption in the short-term and long-term. Accordingly, the objectives of this paper are three-fold. The first objective is to acknowledge that countries are not uniformly globalized; thus, it is important to examine the links between energy consumption and globalization level in the most globalized countries to investigate the long-run and short-run impacts of globalization on energy consumption. The second is to apply a multivariate energy demand function by incorporating economic growth and capital as additional determinants of energy consumption. The third is to investigate the asymmetric quantiles of energy consumption and globalization in the short-term and long-term, which has relevance for development sustainability for the two most globalized countries we consider in this paper, namely Ireland and the Netherlands.

This study contributes to the existing literature in three ways. (i) it is a pioneering effort that explores the relationship between globalization and energy consumption in the top two globalized economies i.e. Ireland and the Netherlands in accordance with the KOF index of globalization (globalization.kof.ethz.ch).[2] Several reasons incentivize us to consider the top positions of Ireland and the Netherlands as the most globalized countries. Those two countries have highly open economies in terms of their corporate tax and FDI policies, exports and imports. First, Ireland's standard rate of corporation tax is among the lowest in the world, standing at 12.5%, compared for example to 35% for the United States. Second, the share of exports of goods and services in GDP ranks Ireland among the top 5 out of 148 countries on the list for 2016. Second, Ireland's central location allows it to be crossroads between North

[2] The two top globalized economies are Ireland and Netherlands.

America and Asia. Third, although the original language in Ireland is Gaelic, today the Irish people speak English, the most spoken language in the world. This has a double-advantage. Indeed, on the one hand, the Irish citizens can easily travel and even work in a foreign country. On the second hand, this advantage could also be an incentive for foreigners to visit Ireland and set up businesses to benefit from its geographical location, as this country acts as a connector between the USA and Asia, and from its membership in the European Union which gives access to 500 million people in the EU market.

As regards the Netherlands, the country has a central location in Europe. The Netherlands is a key distribution location as menifested by the volume of import and export activity. Almost 79% of the Dutch exports remain within Europe, particularly Western Europe. The share of exports of goods and services in the Dutch GDP is about 32% in 2013. The Netherlands' Bureau for Economic Policy Analysis estimated that exports accounted for almost half the country's economic growth over the last two decades. This country also has a well-developed logistics infrastructure that eases and increases the connectedness of companies located in the Netherlands with the European market.

There is a void in the literature in this respect, and this paper's objective is to fill it and provide a more accurate and interesting analysis.

(ii) This study introduces location (quantile) asymmetries in the short-term and long-term adjustments between globalization in different varieties and energy consumption, using the Quantile Autoregressive Distributed Lag (QARDL) model of Cho et al. (2015). To our knowledge, this approach is a relatively new addition to the literature.

(iii) By using the QARDL approach, this study tests the stability of the long-term relationship across the quantiles and provides a more flexible econometric framework to examine the links under consideration. Compared to the linear ARDL model, the QARDL model has the advantage of introducing possible asymmetries in the reaction of energy consumption to increases/decreases in globalization under different gradations.

Methodologically, the QARDL model is superior to linear models for at least three reasons. First, the model allows for locational asymmetry, in that the parameters may depend on the location of the dependent variable, energy consumption, within its conditional distribution. Second, the QARDL model simultaneously addresses the long-term relationship between globalization and energy consumption and its associated short-term dynamics across a range of quantiles of the conditional distribution of energy consumption. Third, contrary to this study, certain studies find evidence of lack of cointegration between these time series, using traditional econometric techniques, such as the Johansen cointegration test and the linear ARDL model. This negative outcome could be explained by the existence of quantile-varying cointegration coefficients over the short-term, although the variables continue to move together in the long-term (Xiao, 2009). The QARDL model also allows the cointegrating coefficient to vary over the innovation quantile, as caused by shocks. The QARDL model is also superior to other nonlinear models, such as the Nonlinear Autoregressive Distributed Lag (NARDL) model (Shin et al., 2011), in which nonlinearity is exogenously defined since the threshold is set to zero instead of being determined by a data-driven process. Those reasons make the QARDL a suitable candidate to more accurately model both the nonlinear and asymmetric linkages between globalization and energy consumption in those two top globalized countries[3]. We find that globalization and energy consumption have a quantile cointegration or long-term relationship in the long-term in Ireland and Netherlands but in the short-term globalization is found to not exert any influence on

[3] Therefore, when it comes to relating the process of globalization to the levels of energy consumption, along with simultaneously analyzing the issue of urbanization and economic growth, there are only a few attempts made in the literature for the world's economies in general and developing countries in particular.

energy consumption in both countries. Energy consumption is more responsive to its past own adjustment than to contemporaneous and past variations in globalization in the short-term. This empirical evidence further reveals that, although insignificantly, globalization affects energy consumption positively in Ireland and negatively in the Netherlands.

Several reasons could explain the asymmetric impact of globalization on energy consumption. First, this impact is due to the complexity of the economic systems and the underlying process driving the dynamics of the variables we consider in this paper. Indeed, most economic and financial variables show a nonlinear dynamic pattern over time, which consequently leads to a nonlinear and asymmetric interaction among them. In particular, globalization may influence energy consumption through different channels, such as economic growth, crises and political turmoil. Indeed, recent years have seen the occurrence of several crises (the 1997-1998 Asian crisis; the 2001 internet bubble; the 2007 subprime crisis; and the 2007-2008 world global crisis among others) and several wars and terrorist attacks (the first and second Gulf wars in 1990-1991 and 2003, respectively; the September 11, 2001 attack; and the numerous terrorist attacks in several countries since the birth of the Arab spring). All the previous factors contribute to destabilize the world's economic system, leading to agents' mobility between countries and regions with more important flows of refugees abandoning their home countries due to poverty and political conditions. Moreover, the world's political map is changing with fewer physical borders and more flexibility regarding the movements of capital, technology and people. The recent Brexit in 2016 is an applicable example of economic disintegration. Under the above conditions, the mutual influence between the economic and financial variables is likely to behave in asymmetric and nonlinear manners.

The remainder of this study is organized as follows. Section 2 reviews the related literature. Section 3 discusses the methodology and data collection. Section 4 discusses the empirical results. Section 5 presents the conclusion and policy implications.

2. **Literature review**

This section reviews different strands of the literature by examining globalization channels and the linkages between globalization and energy consumption for developing, developed and mixed groupings of countries and exploring new perspectives that explain more variables of relevance to the relationship between globalization and energy consumption than what is available in the existing literature.

The current literature provides an exposition of globalization channels, showing how globalization affects energy consumption. The first channel is the scale effect, which suggests that globalization will cause an increase in energy consumption associated with increases in the scale of economic activity, holding all other factors constant (Cole, 2006). The second channel is the technique effect, which views globalization as a factor empowering economies to reduce energy consumption by importing new technologies without reducing the economic activity level (Antweiler et al., 2001; Dollar and Kraay, 2004). The third channel is the composition effect of globalization on energy consumption, which suggests that energy consumption decreases as a result of increases in economic activity (Stern, 2007).

More recently, the linkage between energy consumption and economic growth has expanded to explain the new developments in the existing literature which assert that economic growth rates are sensitive to certain country-specific features, including the level of urbanization, the degree of economic openness, the degree of economic and political stability, regulatory reforms, the degree of a country’s globalization, and the impact of economic growth on a country’s environment (Shahbaz et al., 2015). Therefore, globalization is added as an additional variable in the explanation of economic growth. Various proxies measuring globalization, such as exports, imports, trade, and trade liberalization, have also been utilized in examining the relationship between globalization and energy consumption (Shahbaz et al., 2016).

Researchers have added other possible driving forces to study the energy consumption-economic growth nexus by examining the relationship between these two variables. Since most of the studies in this group are recent, we will focus on the period from 1970Q1 to 2015Q4. For example, Antweiler et al. (2001) find that international trade would increase the income level of developing nations, which will subsequently encourage them to import new technologies that transmit fewer pollutants. Cole (2006) investigates the impact of trade liberalization on per capita energy use for 32 developed and developing countries and finds that trade liberalization increases per capita energy use. Tsani (2010) reports a unidirectional causality running from energy consumption to real GDP at the aggregate level in Greece and a bidirectional causality between industrial and residential energy consumption and real GDP at the disaggregate level. Moreover, the author detects no causality between transport energy consumption and real GDP in either direction in Greece. By employing panel data models and provincial data, Wang et al. (2011) find the existence of a bidirectional positive causality between economic growth and energy consumption in China.

Certain studies have examined the causality between globalization and energy consumption for developing countries. Narayan and Smyth (2009) investigate the causal relationship between energy consumption, exports (as an indicator of globalization) and economic growth for six Middle Eastern countries (Iran, Israel, Kuwait, Oman, Saudi Arabia, and Syria) and confirm the hypothesis of a statistically significant feedback effect between exports and energy consumption. Indeed, a 1% increase in exports increases GDP by 0.17%, and a 1% increase in GDP increases electricity consumption by 0.95%. Using a panel data of eight Middle Eastern countries, Sadorsky (2011) examines the trade-energy consumption relationship for Middle Eastern countries and shows a short-term causality running from exports to energy consumption, as well as a bi-directional causality between imports and energy consumption. Sadorsky (2012) investigates the relationships among energy consumption, output and trade for a sample of seven South American countries and shows that energy consumption resulted in imports and finds a feedback effect between energy consumption and exports. Hossain (2012) examines the relationship between exports and energy consumption for Bangladesh, India and Pakistan and finds evidence that validates the presence of a neutral effect between exports and energy consumption (i.e., exports and energy consumption are independent). Lean and Smyth (2010) analyze the relationship among economic growth, energy consumption and international trade in Malaysia and their empirical evidence underscores the presence of a unidirectional Granger causality running from exports to energy consumption.

The relationship among economic growth, energy consumption, and international trade are also examined in China by Shahbaz et al., (2013a). Those researchers' empirical results show a feedback effect between international trade and energy consumption. Zhang et al., (2013) examine the impact of domestic trade on regional energy demand in China and report a positive impact of trade on regional energy use. Using data from the Turkish economy, Ozturk and Acaravci (2013) study the relationships among economic growth, energy consumption, financial development and trade openness. They assert that economic growth and trade openness cause energy consumption. Shahbaz et al. (2013b) make a similar attempt to investigate the causalities among natural gas consumption, exports and economic growth in Pakistan. Those researchers report that natural gas consumption contributes to exports and economic growth.

Other studies investigate the relationship between energy consumption and globalization in developed countries. Sami (2011) measures the relationship between energy consumption, exports and economic growth in Japan, and the empirical evidence indicates that electricity consumption has a Granger causality with exports. The relationships among energy consumption, exports and imports for 25 OECD countries are also examined by Dedeoglu and Kaya (2013). Those authors document the existence of a bidirectional causality between energy and GDP, energy and exports, and energy and imports.

There are studies that target mixed groupings of countries. Using a panel from 15 Asian countries, Nasreen and Anwer (2014) examine the trade-energy-growth nexus and assert that energy consumption is positively impacted by economic growth and trade openness. Utilizing a heterogeneous panel and Granger causality, Shahbaz et al. (2014a) test the connection between trade openness and energy consumption for 91 low, middle and high income countries. Those authors show a U-shaped relationship between trade openness and energy consumption for low income countries but also find an inverse relationship for high income countries.

Currently, researchers have attempted to generate several perspectives to rationalize the relationship between energy consumption and economic growth by including additional variables (Ozturk, 2010; Apergis and Tang, 2013). An issue of considerable importance is whether the level of globalization of a country can be a contributing factor to the relationship between energy consumption and economic growth. The recent energy literature also emphasizes the considerable importance of linking the process of globalization with the levels of energy consumption. For example, for India, Shahbaz et al., (2016) explore the association between globalization and energy consumption by using sub-indices of globalization, such as economic, social and political globalization factors. The authors' empirical results indicate that globalization (economic and social globalization) decreases energy consumption. Those authors also demonstrate a uni-directional causal association between globalization (economic, social and political globalization) and energy consumption. Furthermore, the effect of globalization on energy consumption may differ with time; thus, it is useful to distinguish between the short-term and long-term effects. Therefore, the net effect of globalization on energy consumption should be examined by considering the implications of globalization on sustainable economic development.

However, all previous studies examine the impact of globalization on energy consumption at the conditional mean or center and ignore the crucial issue that energy consumption may be different across different quantiles of the conditional distribution of energy consumption. There are also many reasons that explain the direction of causal effect of globalization on energy consumption. On the one hand, certain authors argue that energy consumption is positively linked to globalization. Indeed, globalization encourages foreign direct investment and results in larger economic and trade activity, as well as a transfer of technology from developed to developing countries, leading to higher energy consumption (Soytas et al., 2007). On the other hand, certain authors (e.g., Wheeler, 2000) argue that globalization enhances investment in energy efficient production technologies in countries with high environmental regulations, leading to a negative link between globalization and energy consumption. The previous analysis shows that the relationship between globalization and energy consumption is very complex, and thus linear models fail to incorporate all this complexity.

3. Methodology and data collection

To investigate the cointegration relationship between globalization and energy consumption for the top-two globalized countries across quantiles, we use the recently developed QARDL model constructed by Cho et al. (2015). As indicated earlier, the QARDL model allows for testing the quantile long-term equilibrium impact of globalization on energy consumption. The time-varying integration relationship is also tested by using the Wald test, which permits checking the constancy of integrating coefficients across the quantiles. The ARDL model is written as follows:

$$EC_t = \alpha + \sum_{i=1}^{p} \varphi_i EC_{t-i} + \sum_{i=0}^{q_1} \omega_i G_{t-i} + \sum_{i=0}^{q_2} \lambda_i GDP_{t-i} + \sum_{i=0}^{q_3} \theta_i K_{t-i} + \varepsilon_t \qquad (1)$$

where ε_t is the error term defined as $EC_t - E[EC_t / F_{t-1}]$, with F_{t-1} being the smallest $\sigma - field$ generated by $\{G_t, GDP_t, K_t, EC_{t-1}, G_{t-1}, GDP_{t-1}, K_{t-1}, ...\}$, and p, q_1, q_2 and q_3 are lag orders selected by the Schwarz information criteria (SIC). In Equation (1), G_t, GDP_t and K_t refer to the logarithm of globalization, gross domestic product measure of economic growth and capital, respectively, while EC_t represents energy consumption expressed in logarithm form.

Cho et al. (2015) extended the model in Equation (1) to a quantile context and introduced the following basic form of the QARDL (p, q) model:

$$Q_{EC_t} = \alpha(\tau) + \sum_{i=1}^{p} \varphi_i(\tau) EC_{t-i} + \sum_{i=0}^{q_1} \omega_i(\tau) G_{t-i} + \sum_{i=0}^{q_2} \lambda_i(\tau) GDP_{t-i} + \sum_{i=0}^{q_3} \theta_i(\tau) K_{t-i} + \varepsilon_t(\tau) \qquad (2)$$

where $\varepsilon_t(\tau) = EC_t - Q_{EC_t}(\tau / F_{t-1})$ and $Q_{EC_t}(\tau / F_{t-1})$ is the τth quantile of EC_t conditional on the information set F_{t-1} defined above (Kim and White, 2003). To analyze the QARDL, we reformulate Equation (2) as:

$$Q_{EC} = \alpha(\tau) + \sum_{i=1}^{q_1-1} \delta_{G_i}(\tau)\Delta G_{t-1} + \gamma_G(\tau)G_t + \sum_{i=1}^{q_2-1} \delta_{GDP_i}(\tau)\Delta GDP_{t-1} + \gamma_{GDP}(\tau)GDP_t$$
$$\sum_{i=1}^{q_3-1} \delta_{K_i}(\tau)\Delta K_{t-1} + \gamma_K(\tau)K_t + \varepsilon_t(\tau) \quad (3)$$

where $\gamma_G(\tau) = \sum_{i=0}^{q_1} \omega_i(\tau)$, $\delta_{Gt}(\tau) = -\sum_{j=i+1}^{q_1} \omega_i(\tau)$, $\gamma_{GDP}(\tau) = \sum_{i=0}^{q_1} \lambda_i(\tau)$, $\delta_{GDPt}(\tau) = -\sum_{j=i+1}^{q_1} \lambda_i(\tau)$,

$\gamma_K(\tau) = \sum_{i=0}^{q_1} \theta_i(\tau)$ and $\delta_{K_t}(\tau) = -\sum_{j=i+1}^{q_1} \theta_i(\tau)$

The parameters in Equation (3) measure the short-term dynamics, while the long-term relationships between globalization and energy consumption can be captured by reformulating Equation (3) as follows in Equation (4):

$$Q_{EC_t} = \mu(\tau) + X_t^{'}\beta(\tau) + M_t(\tau) \quad (4)$$

with $X = [G, GDP, K]$ and where $\beta_G(\tau) = \gamma_G(\tau)[1 - \sum_{i=1}^{p} \varphi_{G\,i}(\tau)]^{-1}$

and $M_t(\tau) = \sum_{j=0}^{\infty} \partial_{G\,j}(\tau)\Delta G_{t-1} + \sum_{j=0}^{\infty} \theta_{G\,j}(\tau)\Delta\varepsilon_{t-1}$,

with $\mu(\tau) = \alpha(\tau)[1 - \sum_{i=1}^{p} \varphi_i(\tau)]^{-1}$ and $\partial_j(\tau) = \sum_{l=j+1}^{\infty} \pi_l(\tau)$. $\beta_{GDP}(\tau)$ and $\beta_K(\tau)$ are computed in a similar manner.

$\{\theta_0(\tau), \theta_1(\tau), ...$ and $\{\pi_0(\tau), \pi_1(\tau), ...$ are defined such that $\sum_{i=0}^{\infty} \theta_i(\tau) L^i = (1 - \sum_{i=1}^{p} \varphi_i(\tau) L^i)^{-1}$ and

$$\sum_{i=0}^{\infty} \pi_i(\tau) L^i = (1-L)^{-1} \left(\frac{\sum_{i=0}^{q_1} \omega_i(\tau) L^i}{1 - \sum_{i=1}^{q_1} \omega_i(\tau) L^i} - \frac{\sum_{i=0}^{q_1} \omega_i(\tau)}{1 - \sum_{i=1}^{q_1} \omega_i(\tau)} \right)$$

To avoid the serial correlation of ε, we generalize the QARDL as follows:

$$Q_{\Delta EC_t} = \alpha + \rho EC_{t-1} + \varphi_G G_{t-1} + + \varphi_{GDP} GDP_{t-1} + \varphi_K K_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta EC_{t-1} + \sum_{i=0}^{q_1 - 1} \omega_i \Delta G_{t-1}$$
$$+ \sum_{i=0}^{q_2 - 1} \lambda_i \Delta GDP_{t-1} + \sum_{i=0}^{q_3 - 1} \theta_i \Delta K_{t-1} + \nu_t(\tau) \qquad (5)$$

Using the model in Equation (5), there remains a likelihood of contemporaneous correlation between ν_t and ΔG_t, ΔGDP_t and ΔK_t. The previous correlations can be avoided by employing the projection of ν_t on ΔG_t, ΔGDP_t and ΔK_t with the form $\nu_t = \gamma_G \Delta G_t + \gamma_{GDP} \Delta GDP_t + \gamma_K \Delta K_t + \varepsilon_t$. The resulting innovation ε_t is now uncorrelated with ΔG_t, ΔGDP_t and ΔK_t. Incorporating the previous projection into Equation (5) and generalizing it to the quantile regression framework leads to the following QARDL-ECM model:

$$Q_{\Delta EC_t} = \alpha(\tau) + \rho(\tau)(EC_{t-1} - \beta_G(\tau) G_{t-1} - \beta_{GDP}(\tau) GDP_{t-1} - \beta_K(\tau) K_{t-1}) + \sum_{i=1}^{p-1} \varphi_i(\tau) \Delta EC_{t-1} +$$
$$\sum_{i=0}^{q_1 - 1} \omega_i(\tau) \Delta G_{t-1} \sum_{i=0}^{q_2 - 1} \lambda_i(\tau) \Delta GDP_{t-1} + \sum_{i=0}^{q_3 - 1} \theta_i(\tau) \Delta K_{t-1} + \varepsilon_t(\tau) \qquad (6)$$

The cumulative short-term impact of the previous energy consumption on current energy consumption is measured by $\varphi_* = \sum_{j=1}^{p-1} \varphi_j$, while the cumulative short-term impact of current and past levels of globalization, gross domestic product and capital on current energy consumption are measured by $w_* = \sum_{j=1}^{q_1-1} w_j$, $\lambda_* = \sum_{j=1}^{q_2-1} \lambda_j$ and $\theta_* = \sum_{j=1}^{q_3-1} \theta_j$, respectively. The long-term cointegrating parameters for globalization, gross domestic product and capital are calculated as $\beta_{G*} = -\frac{\varphi_G}{\rho}$, $\beta_{GDP*} = -\frac{\varphi_{GDP}}{\rho}$ and $\beta_{K*} = -\frac{\varphi_K}{\rho}$, respectively. The cumulative short-term parameters and the long-term cointegrating parameters are calculated using the delta method. It is worth noting that the ECM parameter ρ should be significantly negative.

To statistically investigate the short-term and long-term nonlinear and asymmetric impacts of globalization on energy consumption, we use the Wald test. The Wald test asymptotically follows a Chi-squared distribution and is used to test the following null and alternative hypotheses for the short-term and long-term parameters φ_* , w_* , β_* and ρ_*:

$H_0^{\varphi} : F\varphi_*(\tau) = f$ versus $H_1^{\varphi} : F\varphi_*(\tau) \neq f$

$H_0^{\varphi} : S\omega_*(\tau) = s$ versus $H_1^{\varphi} : S\omega_*(\tau) \neq s$

$H_0^{\varphi} : S\beta_{i*}(\tau) = s$ versus $H_1^{\varphi} : S\beta_{i*}(\tau) \neq s$

$H_0^{\varphi} : S\rho_*(\tau) = s$ versus $H_1^{\varphi} : S\rho_*(\tau) \neq s$

where F and f are $h*ps$ and $h*1$ are pre-specified matrices, and $\boldsymbol{S}$ and $\boldsymbol{s}$ are $h*s$, and $h*1$ are pre-specified matrices with h being the number of restrictions (Cho et al. 2015)[4] and i denotes respectively G, GDP and K. Specifically, we run the Wald test to investigate the nonlinearities on the speed of the adjustment parameter and the long-term integrating parameter. For each country and each parameter, we run four tests. For example, we test the following null hypothesis for the ρ_* parameter $H_0 : \rho_*(0.05) = \rho_*(0.10) = \rho_*(0.20) = \rho_*(0.30) = \cdots = \rho_*(0.90) = \rho_*(0.95)$ against the alternative $H_a : \exists i \setminus \rho_*(i) \neq \rho_*(j)$ with $i, j \in \{0.05, 0.10, 0.20, \cdots, 0.80, 0.90, 0.95\}$ and $i \neq j$. The same hypotheses are tested on the β_G, β_{GDP} and β_K parameters and on the four cumulative short-term parameters φ_*, w_*, λ_* and θ_*.

We have chosen the sample countries, i.e., the top-two globalized economies, in accordance with the KOF index of globalization (globalization.kof.ethz.ch) developed by Dreher (2006), as indicated earlier, to compare their empirical results by investigating the association between globalization and energy consumption by incorporating economic growth and capital in energy demand function. We have used energy use (kt of oil equivalent) as a measure of energy consumption, gross domestic product (constant 2010 US$) as a proxy for economic growth and gross fixed capital formation (constant 2010 US$) as a measure of capital. These data are obtained from the World Development Indicators (CD-ROM, 2015). The total population is utilized to transform the data into per capita units. All the previous data are retrieved at the annual frequency and then transformed into quarterly data following Sbia et al. (2014) by using the quadratic match-sum method. The variables have then been transformed into natural logarithmic forms. The globalization index is derived from Dreher (2006). This overall index is

[4]See cho et al. (2015) for a detailed definition of the Wald statistics.

constructed from three sub-indices: the economic globalization, the social globalization and the political globalization. The economic globalization includes actual economic flows (i.e., trade, foreign direct investment and portfolio investment) and constraints on trade and capital using hidden import barriers, such as tariff rates and taxes on international trade. The social globalization is defined in the form of sharing cultures and languages among countries and is measured by the number of embassies in a country and the membership in international organizations. Finally, the participation in the UN Security Council and international treaties is used to generate an index of political globalization. The time period is from 1970Q1 to 2015Q4.

< Insert Table 1 here >

< Insert Table 2 here >

Table 1 reports the descriptive statistics of the energy consumption and globalization data in the Netherlands and Ireland. The results indicate that in the average the Netherlands consumes more energy and shows a higher level of globalization than Ireland. This finding highlights the role of globalization in rising energy consumption in those countries. The energy consumption data in both countries show a higher variability, as compared to the globalization data. Globalization data are negatively skewed while energy consumption is negatively skewed in the Netherlands, but positively skewed in Ireland. This means that the globalization and energy consumption data in the Netherlands have longer right tails than the normal distribution. Energy consumption has also fatter tails than a normal distribution in the Netherlands and, together with globalization data in both countries, it has thinner tails than the normal distribution in Ireland. The Jarque-Bera statistics also show that energy consumption and globalization data deviate from the normal distribution.

Prior to estimating the QARDL model, it is important to check for the order of integration of the time series in our data set. We thus performed the augmented Dickey-Fuller (ADF) and Zivot-Andrews (1992) (ZA) unit root tests and reported the results in Table 2. The ZA test has the advantage of accounting for a structural break in the data. The results show that all the time series are I(1) in the Netherlands and Ireland, except energy consumption which is found to be I(0), and thus stationary as the ADF and ZA tests reject the null of unit root at the 10% and 5% significance levels, respectively. This qualifies the QARDL model to be an appropriate model for this study.

4. Empirical results and discussion

The OLS estimation results for the two top globalized countries show that there is evidence of linear cointegration between globalization, economic growth, capital and energy consumption for the Netherlands only, since the speed of adjustment coefficient ρ_* for this country is significantly negative, thus having the required negative sign. However, this is not the case for Ireland.

Furthermore, the linear long-term cointegrating parameters between energy consumption and globalization and between energy consumption and gross domestic product are found to be insignificant in those two top globalized countries. Capital is significantly linked to energy consumption in the long-run in the Netherlands, while it is found not to influence energy consumption in the long-run in Ireland. Among those top globalized countries, the slowest reversion speed is recorded for Ireland (1.6%), and the fastest is accorded to the Netherlands (11.2%).

< Insert Table 3 here >

< Insert Table 4 here >

The results of the QARDL model estimation for those top globalized countries show that the estimated parameter ρ_* is highly significant, with the expected negative sign at all quantiles for the Netherlands, indicating that there is a reversion to the long-term equilibrium relationship between energy consumption and globalization. However, ρ_* is significantly negative for Ireland in four out of the eleven considered quantiles in our empirical estimation. The results also show that β_{GLOB} is significant primarily at high quantiles for the Netherlands and at extreme high quantiles for Ireland. It is worth noting that the long-term cointegrating parameter β_{GLOB} is positive for Ireland, indicating an upward trending long-term relationship between energy consumption and globalization. In contrast, the Netherlands has a downward trending long-term relationship between energy consumption and globalization as β_{GLOB} is negative. Indeed, globalization increases energy consumption in Ireland because it leads economic activity. There is a migration of manufacturing and engineering companies (e.g., machinery, automotive, chemicals) from Germany to Ireland. However, in the Netherlands, globalization takes the form of trade and capital inflows, thus allowing the country to import new technology and consequently to reduce energy consumption. Moreover, globalization through information and cultural flows enables local people to acquire better practices available in other countries, which reduces energy consumption for production and consumption activities.

The empirical findings also show that β_{GDP} is significant at the highest quantiles for the Netherlands and at the 10% quantile for Ireland. β_{GDP} is negative for both countries indicating a negative relationship between energy consumption and economic growth. This result supports the energy efficiency hypothesis which asserts that a reduction in energy consumption provides an alternative way to increase economic growth, without damaging the environment. β_K, in turn, is revealed to be significant at the medium quantiles for the Netherlands but at the 10% and 90% quantiles for Ireland. The positive value found for β_K in the two countries corroborates the idea that efficiency and availability of capital supports lending to households and firms, thus encouraging consumers to purchase “large-ticket” items, thus increasing the consumption of energy.

Turning to the analysis of short-term dynamics, the findings show that current energy consumption variations are significantly and positively influenced by their own past levels in the two countries. In the short-term, current and past changes in globalization do not impact current changes in energy consumption in Ireland and the Netherlands. Current and past changes in globalization are found to not impact significantly current variations of energy consumption at all in those two most globalized countries. Although insignificant, the influence of globalization on energy consumption in the short-run is negative in the Netherlands but positive in most of the quantiles in Ireland. Cumulative current and past changes in GDP influence the current changes in energy consumption positively in the Netherlands and negatively in Ireland. The intensity of the latter influence varies across countries, showing an asymmetric influence of economic growth on energy consumption in the short-term. Capital exerts a positive short-term impact on the energy consumption in Ireland, whereas it has a negative contemporaneous influence and a positive influence on energy consumption in the Netherlands. Capital influences energy consumption in the short-term mainly at the low quantiles in Ireland and Netherlands and only at the high quantiles in the Netherlands.

Figures 1 and 2 depict the dynamics of the parameter estimates over the considered quantiles for the Netherlands and Ireland, respectively. A shown in those figures, the estimated parameters display a dissimilar path compared to their respective corresponding linear estimates, indicating that these estimated parameters behave differently across the quantiles.

< Insert Figure 1 here >

< Insert Figure 2 here >

Our results for the corresponding Wald tests show that the null of linearity (i.e., parameter constancy) of the speed of adjustment parameter is rejected for both the Netherlands and Ireland. However, the null hypothesis of the parameter constancy across the quantiles for the long-term integrating parameter β_{GLOB} is rejected for the Netherlands only. This shows that the cointegrating parameter between globalization and energy consumption is dynamic in different quantiles in the Netherlands. This result could be explaining by the fact that the Dutch government has passed through different stages of achieving clean energy strategy. Indeed, the Netherlands has long attracted investment in oil and gas storage. Between 1990 and 2012, the Netherlands aimed at stimulating energy efficiency and innovation in energy-intensive industries but the country remained one of the most CO2-intensive economics. Recently, the Dutch government adopted a work plan to achieve a zero-level greenhouse gase emissions by 2050. The null of parameter constancy across the quantiles regarding β_{GDP} and β_K is accepted for the two countries, meaning that although the parameter estimates β_{GDP} and β_K are different across quantiles they are significant for some quantiles. This difference is not statistically significant.

< Insert Table 5 here >

Regarding the short-term cumulative impact of the past levels of energy consumption estimation, the results indicate that the Wald test strongly rejects the null hypothesis of parameter constancy across the considered quantiles for both the Netherlands and Ireland. The Wald test also rejects the null of parameter constancy regarding the short-term impact of globalization on energy consumption in the Netherlands but fails to reject the null hypothesis of parameter constancy across the quantiles for Ireland. The findings also indicate that GDP exerts an asymmetric contemporaneous and lagged influence on energy consumption in Ireland as the Wald test also strongly rejects the null hypothesis of parameter constancy across the quantiles for both lags. In contrast, GDP is found to exert a symmetric cumulative short-run influence on energy consumption in Ireland and the Netherlands as the Wald test fails to reject the null hypothesis of parameter constancy over the quantiles.

Regarding the short-term impact of capital on energy consumption, the null of parameter constancy is strongly rejected for the Netherlands and Ireland both contemporaneously, and also at the one-lag period for the Netherlands indicating that capital influences energy consumption in an asymmetric manner in the short-run in both countries at the respective lags, as selected by the AIC criterion. A deeper examination of the results of the Wald test indicates that the cumulative short-run impact of capital on energy consumption is symmetric. Indeed, the Wald test fails to reject the null hypothesis of cumulative parameters constancy across the quantiles at the conventional levels of significance.

Although Ireland and the Netherlands are the top globalized countries, some differences are observed in the behavior of the parameter estimates across the quantiles of the energy consumption distribution. The differences may be due to different national statistics in the two countries. Indeed, although the level of globalization is comparable in both countries, however

GDP per capita is much higher in Ireland than in the Netherlands (almost 1.5 times). On the other hand, unemployment rate is higher in Ireland (6%) as compared to that in the Netherlands (4.5%). In contrast, the stock market price return is almost double in the Netherlands (10.85%), compared to that of Irish stock market (5.29%).

5. Conclusion and policy implications

To the best of our knowledge, this is the first study that strives to study the relationships among globalization, economic growth, capital and energy consumption for those top globalized countries, using the quantile distribution for energy consumption, as specified in the QARDL model over the long time sample period, 1970Q1-2015Q4. This analysis is important, since there have been concerns that globalization would result in an increase in energy consumption for nearly all countries, and that the expansion of globalization is usually associated with an expanded use of energy due to the established empirical connection between economic growth and energy demand.

Our results suggest that globalization is strongly related to energy consumption over the long-term for the two top globalized economies. However, the results also indicate that the short-term effect of globalization on energy demand is limited and remains insignificant for those highly globalized countries. This finding is very interesting, as it indicates that a one policy strategy cannot be either constant or homogeneous across time and nations, when considering countries with high levels of globalization.

More importantly, given that the most globalized countries may benefit from globalization-induced new technologies and that the least globalized economies tend to have domestic environmental laws that are laxer than those of the most globalized countries, our study supports the view that policy makers should not worry about the negative environmental consequences of globalization. Furthermore, given that information and knowledge can currently be characterized as considerably accessible, it appears that the positive environmental effects of globalization would dominate the negative effects. This supposition is very true considering that corporate globalization is widespread, therefore, corporations will be more involved in transferring clean technology from developed to developing countries.

The findings also indicate that economic growth is related to energy consumption in the long-term in the Netherlands and Ireland. Furthermore, capital strongly impacts energy consumption in both countries. In the short-term, economic growth influences energy consumption in the two considered countries.

The empirical results also imply there are certain challenges for policy-makers in their pursuit of adequate environmental reforms. The long-term impacts of globalization on energy consumption could neutralize the interest in short-term reforms. Indeed, our results definitely support this notion, as they reveal that energy consumption does not react to globalization in the short-term in the Netherlands and Ireland. Therefore, we recommend that environmental reforms continue over a lengthy period to yield their desired impacts in the long run.

Considering the results reported above, our study stresses the need for creating serious continuous cooperation between developed and less developed nations in sharing technologies that reduce pollution in the coming decades. As globalization continues to expand, so will the world's demand for energy, which should raise a range of serious environmental concerns if not addressed soon.

In addition, government interventions encourage local firms to create new job opportunities and to compete domestically and internationally, leading to an improvement in capital formation. It is now highly accepted that capital boosts economic growth. Indeed, the efficient use of capital increases output, which enhances economic growth, which, in turn, leads to higher energy consumption. Government and policy makers should consider the previous transmission channels and causalities to monitor energy consumption by using available instruments, such as subsidies and taxes. The latter instruments may also be used to build capital in the economy. Governments should then use this capital in appropriate proportions to promote capital formation while monitoring energy consumption.

References

1. Antweiler, W., Copeland, B.R. and Taylor, M.S. (2001). Is free trade good for the environment? American Economic Review, 91, 877–908.
2. Apergis, N. and Tang, C. F. (2013). Is the energy-led growth hypothesis valid? New evidence from a sample of 85 countries. Energy Economics, 38, 24-31.
3. Binh, P. T. (2011). Energy consumption and economic growth in Vietnam: threshold cointegration and causality analysis. International Journal of Energy Economics and Policy, 1, 1–17.
4. Bowden, N. and Payne, J. E. (2009). The causal relationship between U.S. energy consumption and real output: a disaggregated analysis. Journal of Policy Modeling, 31, 180–188.
5. Cho, J.S., Kim, T-H. and Shin, Y. (2015). Quantile cointegration in the autoregressive distributed-lag modeling framework. Journal of Econometrics 188, 281-300.
6. Cole, M. A. (2006). Does trade liberalisation increase national energy use? Economics Letters, 92, 108–112.
7. Copeland, B.R. and Taylor, M.S. (2004). Trade, growth and the environment. Journal of Economic Literature, 42, 7–71.
8. Dedeoglu, D. and Kaya, H. (2013). Energy use, exports, imports and GDP: new evidence from the OECD countries. Energy Policy 57, 469–476.

9. Dollar, D. and Kraay, A. (2004). Trade, Growth and Poverty. The Economic Journal, 114 (493), 22-49.
10. Dreher, A. (2006). Does globalization affect growth? Evidence from a new index of globalization. *Applied Economics 38*, 1091-1110.
11. Fuinhas, J. A. and Marques, A. C. (2012). Energy consumption and economic growth nexus in Portugal, Italy, Greece, Spain and Turkey: an ARDL bounds test approach (1965-2009). Energy Economics, 34, 511–517.
12. Gross, C. (2012). Explaining the (non-) causality between energy and economic growth in the U.S. -a multivariate sectoral analysis. Energy Economics, 34, 489–499.
13. Hossain, M. S. (2012). Multivariate Granger causality between economic growth, electricity consumption, exports and remittance for the panel of three SAARC countries. Global Journal of Management and Business Research 12, 40–54.
14. Jena, P. R. and Grote, U. (2008). Growth-trade-environment nexus in India. Economics Bulletin, 17(11), 1-17.
15. Kaplan, M., Ozturk, I. and Kalyoncu, H. (2011). Energy consumption and economic growth in Turkey: co-integration and causality analysis. Romanian Journal of Economic Forecasting, 2, 31–41.
16. Lean, H.H. and Smyth, R. (2010). On the dynamics of aggregate output, electricity consumption and exports in Malaysia: evidence from multivariate Granger causality tests. Applied Energy 87, 1963–1971.
17. Narayan, P. K. and Smyth, R. (2009). Multivariate Granger causality between electricity consumption, exports and GDP: evidence from a panel of Middle Eastern countries. Energy Policy 37, 229–236.
18. Nasreen, S. and Anwer, S. (2014). Causal relationship between trade openness, economic growth and energy consumption: a panel data analysis of Asian countries. Energy Policy 69, 82–91.
19. Ozturk, I. (2010). A literature survey on energy-growth nexus. Energy Policy, 38(1), 340-349.
20. Ozturk, I. and Acaravci, A. (2013). The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. Energy Economics 36, 262–267.

21. Sa'ad, S. (2010). Energy consumption and economic growth: causality relationship for Nigeria. OPEC Energy Review, 34, 15–24.
22. Sadorsky, P. (2011). Trade and energy consumption in the Middle East. Energy Economics 33, 739–749.
23. Sadorsky, P. (2012). Energy consumption, output and trade in South America. Energy Economics 34, 476–488.
24. Sami, J. (2011). Multivariate cointegration and causality between exports, electricity consumption and real income per capita: recent evidence from Japan. International Journal of Energy Economics and Policy 1, 59–68.
25. Sbia, R., Shahbaz, M. and Hamdi, H. (2014). A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE. Economic Modelling 36, 191-197.
26. Shahbaz, M., Lean, H. H. and Farooq, A. (2013a). Natural gas consumption and economic growth in Pakistan. Renewable and Sustainable Energy Reviews, 18, 87–94.
27. Shahbaz, M., Lean, H.H. and Farooq, A. (2013b). Natural gas consumption and economic growth in Pakistan. Renewable and Sustainable Energy Reviews 18, 87–94.
28. Shahbaz, M., Mallick, H., Mahalik, M. K. and Sadorsky, P. (2016). The role of globalization on the recent evolution of energy demand in India: Implications for sustainable development. Energy Economics 55, 52–68.
29. Shahbaz, M., Nasreen, S., Ling, C. H. and Sbia, R. (2014). Causality between trade openness and energy consumption: What causes what in high, middle and low-income countries. Energy Policy 70, 126–143.
30. Shahbaz, M., Saleheen, K. and Tahir, M. I. (2013a). The dynamic link between energy consumption, economic growth, financial development and trade in China: fresh evidence from multivariate framework analysis. Energy Economics 40, 8–21.
31. Shahbaz, M., Zeshan, M. and Afza, T. (2012). Is energy consumption effective to spur economic growth in Pakistan? New evidence from bounds test to level relationships and Granger causality tests. Economic Modelling, 29, 2310–2319.
32. Shahbaz, M., Shahzad, S. J. H., Mahalik, M. K. and Sadorsky, P. (2017). How strong is the causal relationship between globalization and energy consumption in developed economies? A country-specific and panel data analysis. Applied Economics. *Forthcoming*.

33. Shin, Y., Yu, B., Greenwood-Nimmo, M. (2011). Modelling asymmetric cointegration and dynamic multipliers in an ARDL framework. In: Horrace, William C., Sickles, Robin C. (Eds.), Festschrift in Honor of Peter Schmidt. Springer Science & Business Media, New York (NY).
34. Soytas, U., Sari, R. and Ewing, B. T. (2007). Energy consumption, income, and carbon emissions in the United States. Ecological Economics, 62, 482–489.
35. Stern D. I. (2007). The effect of NAFTA on energy and environmental efficiency in Mexico. Policy Studies Journal 35(2), 291-322.
36. Tsani, S. Z. (2010). Energy consumption and economic growth: a causality analysis for Greece. Energy Economics, 32, 582–590.
37. Wang, S. S., Zhou, D. Q., Zhou, P. and Wang, Q. W. (2011). CO2 emissions, energy consumption and economic growth in China: a panel data analysis. Energy Policy, 39, 4870–4875.
38. Xiao,Z. (2009)uantile cointegrating regression. Journal of Econometrics150, 248–260.
39. Zhang, D., Sebastian, R., Karplus, V.J. and Zhang, X. (2013). Quantifying regional economic impacts of CO2 intensity targets in China. Energy Economics 40, 687–701.

Table 1: Descriptive Statistics

	Energy consumption		Globalization	
	Netherlands	Ireland	Netherlands	Ireland
Mean	1125.555	702.878	20.841	19.780
Max	1261.952	930.004	23.025	23.308
Min	932.7601	470.222	16.067	15.787
Sd. dev	71.928	124.658	2.086	2.205
Skewness	-0.874	0.235	-0.745	-0.221
Kurtosis	3.495	1.847	2.294	1.945
JB	25.316 [0.000]	11.884 [0.002]	20.865 [0.000]	10.023 [0.007]

Notes: JB denotes the empirical statistics of the Jarque-Bera test for normality.

Table 2: Stationarity test results

	ADF (level)	ADF (Δ)	ZA (level)	ZA (Δ)
Panel A : Energy consumption				
The Netherlands	-2.669^{*b}	-4.328^{***c}	-5.120**	-7.374***
Ireland	0.262^{c}	-3.113^{***c}	-4.420	-7.182***
Panel B : Globalization				
The Netherlands	-1.931^{b}	-2.686^{***c}	-4.585	-6.695***
Ireland	-2.713^{a}	-2.923^{**b}	-4.198	-6.307***
Panel C : Gross Domestic Product				
The Netherlands	-1.811^{b}	-2.015^{**c}	-3.308	-5.549**
Ireland	-1.864^{b}	-3.692^{***b}	-4.696	-5.812***
Panel D : Capital				
The Netherlands	-2.983^{a}	-2.893^{***c}	-4.080	-5.495**
Ireland	-2.821^{a}	-3.127^{***c}	-3.809	-6.004***

Notes: The numbers in this table indicate the empirical values of the ADF and ZA tests' statistics for stationarity. The letters a, b and c refer to the model with trend and intercept, the model with intercept and the model without trend and intercept, respectively. The asterisks ***, ** and * indicate a rejection of the null of a unit root at the respective significance levels of 1%, 5% and 10%, respectively. The critical values for the ZA test are -5.57 (1%), -5.08 (5%) and -4.82 (10%).

Table 3: OLS and Quantile Estimation Results for Ireland

OLS estimation results										
	α_*	ρ_*	β_{GLOB}	β_{GDP}	β_K	φ_1	ω_0	λ_0	λ_1	ω_0
	-0.132	-0.016	0.318	-0.483	1.179	0.515***	0.051	-0.152***	0.107***	0.080**
	(0.102)	(0.012)	(0.303)	(0.474)	(0.781)	(0.065)	(0.033)	(0.038)	(0.037)	(0.037)
(τ)	$\alpha_*(\tau)$	$\rho_*(\tau)$	$\beta_{GLOB}(\tau)$	$\beta_{GDP}(\tau)$	$\beta_K(\tau)$	$\varphi_1(\tau)$	$\omega_0(\tau)$	$\lambda_0(\tau)$	$\lambda_1(\tau)$	$\omega_1(\tau)$
0.05	-0.302	-0.041	0.321	-0.334	0.845	0.460***	-0.423	-0.395***	0.257***	0.079
	(0.301)	(0.026)	(0.239)	(0.357)	(0.598)	(0.121)	(0.592)	(0.098)	(0.070)	(0.083)
0.1	-0.454*	-0.025*	0.505*	-0.776**	1.982**	0.372***	0.059	-0.201*	0.082	0.119**
	(0.253)	(0.014)	(0.291)	(0.322)	(0.956)	(0.104)	(0.424)	(0.102)	(0.063)	(0.047)
0.2	-0.332**	-0.002	3.486	-5.720	10.348	0.343***	0.251	-0.207***	0.091**	0.153***
	(0.126)	(0.009)	(11.889)	(14.697)	(42.768)	(0.096)	(0.366)	(0.052)	(0.037)	(0.047)
0.3	-0.232***	-0.004	1.491	-2.576	4.922	0.430***	0.241	-0.157***	0.076**	0.105**
	(0.075)	(0.003)	(1.478)	(3.823)	(8.080)	(0.082)	(0.307)	(0.038)	(0.033)	(0.045)
0.4	-0.227***	-0.005*	1.235	-1.974	3.513	0.427***	0.356	-0.121***	0.061*	0.078
	(0.066)	(0.003)	(0.815)	(2.077)	(3.052)	(0.081)	(0.259)	(0.031)	(0.032)	(0.048)
0.5	-0.190***	-0.003	1.945	-3.030	4.778	0.494***	0.371	-0.120***	0.079***	0.073*
	(0.071)	(0.004)	(3.338)	(5.738)	(8.453)	(0.077)	(0.249)	(0.029)	(0.029)	(0.038)
0.6	-0.169**	-0.004	0.972	-2.620	5.677	0.424***	0.247	-0.107***	0.058*	0.030
	(0.072)	(0.008)	(2.438)	(3.341)	(9.417)	(0.059)	(0.320)	(0.040)	(0.033)	(0.030)
0.7	-0.133**	-0.011	0.376	-0.800	1.775	0.472***	0.454	-0.074*	0.075*	0.018
	(0.067)	(0.012)	(0.368)	(0.618)	(1.620)	(0.056)	(0.369)	(0.041)	(0.039)	(0.029)
0.8	-0.138	-0.025	0.278	-0.424	0.923	0.485***	0.267	-0.042	0.066*	0.012
	(0.112)	(0.022)	(0.234)	(0.391)	(0.572)	(0.049)	(0.344)	(0.052)	(0.035)	(0.037)
0.9	-0.001	-0.071**	0.151**	-0.109	0.386**	0.433***	0.081	-0.011	0.031	0.015
	(0.119)	(0.029)	(0.065)	(0.082)	(0.156)	(0.084)	(0.251)	(0.055)	(0.039)	(0.052)
0.95	0.155	-0.077*	0.165***	-0.062	0.042	0.762***	-0.392	0.021	0.091*	-0.031
	(0.135)	(0.004)	(0.049)	(0.078)	(0.277)	(0.159)	(0.372)	(0.070)	(0.055)	(0.060)

Notes: The table reports the OLS and quantile estimation results. The standard errors are between brackets. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. The *p* and *q* lag lengths in Eq. (6) are selected using the Schwarz Information Criteria such that p = 6; *q* = 1. $\alpha_* = \alpha \ and \ \rho_* = \rho$.

Table 4: OLS and Quantile Estimation Results for the Netherlands

OLS estimation result										
α_*	ρ_*	β_{GLOB}	β_{GDP}	β_K	φ_1	φ_2	ω_0	λ_0	θ_0	θ_1
0.731*** (0.164)	-0.112*** (0.021)	-0.311 (0.213)	0.043 (0.033)	0.145** (0.063)	0.542*** (0.068)	0.168** (0.069)	-0.035 (0.026)	0.045 (0.028)	-0.445*** (0.079)	0.344*** (0.078)

Quantile estimation results											
(τ)	$\alpha_*(\tau)$	$\rho_*(\tau)$	$\beta_{GLOB}(\tau)$	$\beta_{GDP}(\tau)$	$\beta_K(\tau)$	$\varphi_1(\tau)$	$\varphi_2(\tau)$	$\omega_0(\tau)$	$\lambda_0(\tau)$	$\theta_0(\tau)$	$\theta_1(\tau)$
0.05	0.684*** (0.246)	-0.144*** (0.029)	0.117 (0.369	-0.029 (0.072)	0.269** (0.123)	0.704*** (0.136)	0.384*** (0.142)	-0.414 (0.487)	0.034 (0.053)	-0.356* (0.210)	0.483** (0.198)
0.1	0.741** (0.291)	-0.129*** (0.031)	-0.060 (0.395)	0.031 (0.060)	0.151* (0.078)	0.527*** (0.096)	0.274** (0.110)	-0.610 (0.782)	0.017 (0.063)	-0.343 (0.236)	0.337 (0.236)
0.2	0.524*** (0.184)	-0.094*** (0.029)	0.044 (0.247)	-0.011 (0.031)	0.184* (0.106)	0.408*** (0.089)	0.180** (0.084)	-0.446 (0.623)	0.033 (0.044)	-0.247 (0.242)	0.213 (0.203)
0.3	0.390*** (0.078)	-0.072*** (0.012)	0.248 (0.273)	-0.032 (0.039)	0.149 (0.117)	0.400*** (0.074)	0122** (0.053)	-0.092 (0.475)	0.037 (0.029)	-0.278* (0.165)	0.251* (0.151)
0.4	0.334*** (0.086)	-0.066*** (0.011)	0.233 (0.258)	-0.040 (0.049)	0.205* (0.119)	0.355*** (0.070)	0.143*** (0.042)	-0.116 (0.397)	0.036 (0.026)	-0.210 (0.147)	0.179 (0.138)
0.5	0.370*** (0.125)	-0.070*** (0.017)	0.121 (0.255)	-0.039 (0.042)	0.229* (0.136)	0.366*** (0.063)	0.135*** (0.043)	-0.125 (0.390)	0.050* (0.027)	-0.237* (0.133)	0.177 (0.108)
0.6	0.441*** (0.133)	-0.076*** (0.018)	-0.119 (0.240)	-0.016 (0.040)	0.232** (0.109)	0.366*** (0.059)	0.112** (0.044)	-0.160 (0.338)	0.057** (0.027)	-0.196 (0.120)	0.143 (0.092)
0.7	0.677*** (0.208)	-0.104*** (0.028)	-0.411** (0.181)	0.029 (0.027)	0.203*** (0.073)	0.409*** (0.075)	0.101 (0.063)	-0.314 (0.349)	0.048** (0.022)	-0.285** (0.132)	0.191* (0.104)
0.8	0.869*** (0.256)	-0.127*** (0.035)	-0.560*** (0.189)	0.031 (0.033)	0.221** (0.089)	0.430*** (0.090)	0.152** (0.065)	-0.208 (0.527)	0.058 (0.036)	-0.458*** (0.155)	0.267** (0.112)
0.9	0.732* (0.381)	-0.110** (0.053)	-0.514 (0.353)	0.004 (0.078)	0.260 (0.175)	0.506*** (0.119)	0.233** (0.102)	-0.049 (0.564)	0.037 (0.050)	-0.536** (0.262)	0.337* (0.171)
0.95	1.609*** (0511)	-0.210*** (0.072)	-0.705** (0.334)	0.094** (0.042)	0.103 (0.109)	0.690*** (0116)	0.372** (0171)	-0.370 (0.520)	0.052 (0.051)	-0.798** (0.336)	0.478** (0.215)

Notes: The table reports OLS and quantile estimation results. The standard errors are between brackets. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. The *p* and *q* lag lengths in Eq. (6) are selected using the Schwarz Information Criteria and p = 6; q = 1. $\alpha_* = \alpha$ and $\rho_* = \rho$.

Table 5: Wald Test Results

	Ireland	Netherlands
ρ	2.280** [0.016]	4.450*** [0.000]
β_{GLOB}	1.360 [0.202]	4.260*** [0.000]
β_{GDP}	0.950 [0.489]	0.860 [0.568]
β_K	0.700 [0.719]	0.910 [0.524]
φ_1	4.820*** [0.000]	2.140** [0.024]
φ_2		1.770* [0.069]
w_0	1.230 [0.475]	2.420** [0.010]
λ_0	2.880*** [0.002]	0.510 [0.883]
λ_1	1.890* [0.050]	
θ_0	1.750* [0.074]	1.710* [0.082]
θ_1		2.780*** [0.003]
Cumulative short-term effect:		
φ_*		4.970*** [0.000]
λ_*	1.200 [0.292]	
θ_*		1.330 [0.217]

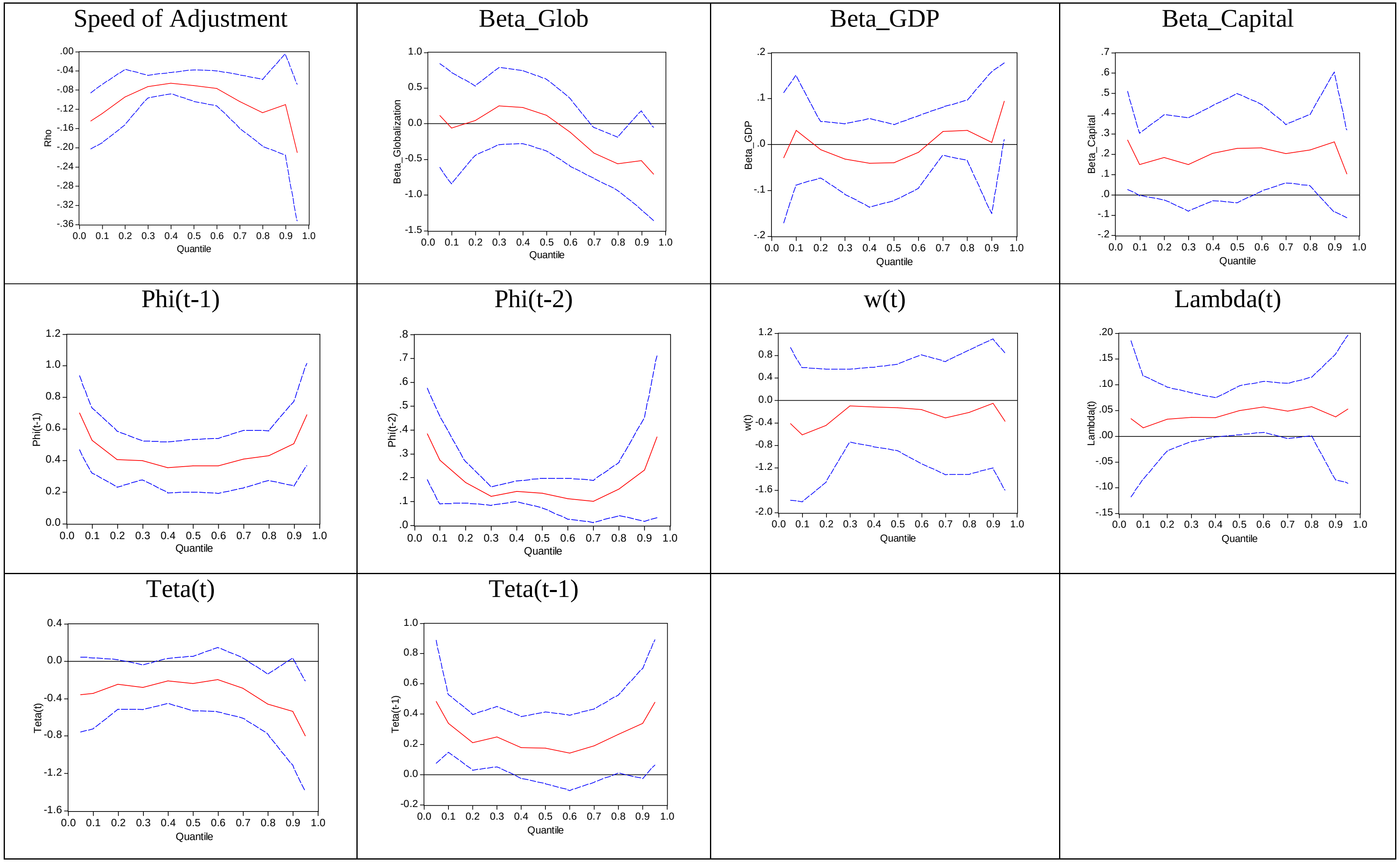

Figure 1: Quantile parameter estimates-The Netherlands.

Notes: The plots show the estimated parameters (middle solid line) on the vertical axis for the quantiles 0.05, 0.1, 0.2,…, 0.9, 0.95 with the 95% confidence interval (outer dotted lines).

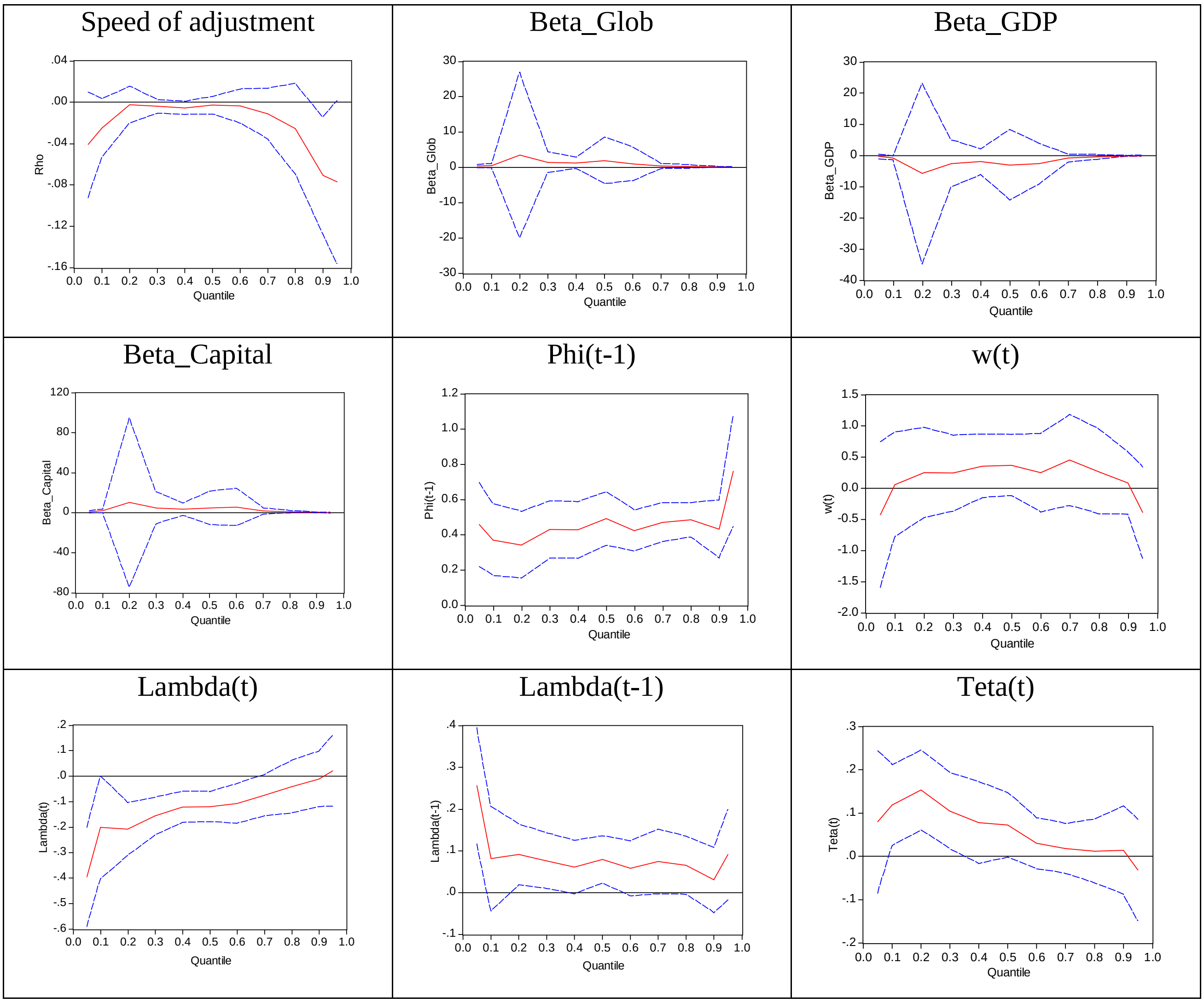

Figure 2: Quantile parameter estimates- Ireland

Notes: The plots show the estimated parameters (the middle solid line) on the vertical axis for the quantiles 0.05, 0.1, 0.2,…, 0.9, 0.95 with the 95% confidence interval (outer dotted lines).